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DISCUSSION OF HYDROLOGY OF MEXICO

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IRRIGATION DIVISION

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DISCUSSION

ANDREW WEISS,[7] Hon. M. ASCE.—A concise and complete description of the hydrologic resources of the Republic of Mexico is presented in this paper, thus affording a comparison of these resources with those of the United States. A careful reading of the paper will reveal that Mexico can never hope to rank very high as a producer of agricultural wealth, and that it is in need of developing its agriculture to as high a degree as possible. It is a country blessed with a magnificent climate that will always attract people seeking such comforts as the State of California provides in the United States. Similar to California, the areas of most attractive climate in Mexico have resulted in a certain shift in the density of population. For these reasons the unit cost of developing irrigation and colonization resources in suitable climates may reach costs considerably higher than the average, a fact which has already been demonstrated in Mexico. It is to be expected that many parts of Mexico will attract a select type of colonist, even from outside its border, who may wish to enjoy the healthful environment. Of the several interesting topics suggested by this paper, seven may be emphasized as follows:

(1) Mexico occupies a relatively dry zone on the face of the globe, dry the entire year between latitudes 19°N to 31°N. More than 75% of the nation is in this belt; and the wettest region is to be found in zone XII (Item No. 5, Table 2). Mexico may be classified as not rainy, despite the fact that tropical rains occur in some southeastern regions.

(2) The orography and geologic structure of Mexico is the cause of the reduced runoff, a condition that is especially noticeable in the preponderant limestone structure so prevalent in the central plateau and the "carstic" regions distributed throughout the republic.

(3) Attention is directed to the relatively short records of river measurements—generally a period of about twenty years, which covers the period during which runoff records have so far been obtained. Doubtless, in the future, there will be some surprises in the occurrence of both maximum and minimum observations.

(4) In general, the Republic of Mexico is not blessed with any large percentage of good agricultural land, such as that which occurs in abundance in large regions of the southern, eastern, and midwestern parts of the United States. Therefore, it will always be necessary to husband the resources represented by its waters and soils so as to develop an agriculture sufficient to support the population which its climatic resources will always invite.

(5) It is clear from Table 3 that storage of the flood waters is an unavoidable necessity in Mexico if its hydraulic resources are to be utilized in conformity with its climatic conditions.

(6) A certain increase of agricultural production may be obtained by pumping the shallow water table over relatively large areas in the so-called Bajio region, an extensive agricultural area in the central part of the republic.

NOTE.—This paper by Andrés García-Quintero was published in October, 1950, as *Proceedings-Separate No. 38*. The numbering of footnotes in this Separate is a continuation of the consecutive numbering used in the original paper.

[7] Cons. Engr., Dept. of Water Resources, Mexico, D. F., Mex.

Large tracts of the present irrigable area in the region of Lower California are now covered by a network of canals for irrigation and drainage in the section watered by the international diversion dam south of Yuma, Arizona. Increased agricultural production is possible in this region. Similarly, most of the agricultural lands on the Yucatan Peninsula must be irrigated by pumping.

(7) A large part of the irrigated and irrigable areas of the republic is located on the flat areas that link the Sierra Madre Occidental with the Gulf of California. Development in this region will require considerable improvement in transportation facilities before products can be moved to the central regions where the principal markets are located.

MILTON O. SCHMIDT,[8] ASSOC. M. ASCE.—An admirable attempt to treat the broad subject of the hydrology of Mexico within the compass of a few pages has not been fully successful in this paper. It still is incomplete, and it lacks the quality of conclusiveness. Its cardinal purpose, as stated in the Synopsis, is "* * * to explain why water * * * is so scarce" in Mexico. In support of this statement the author needs to name the factors that control and affect the disposition of precipitation. In short, he has presented rainfall and runoff data but has cast no light on the effects exercised by such factors as geology, evaporation in its relation to temperature, soil, vegetation, and ground slopes. Hence, one can make only vague conjectures as to why many Mexican streams are not perennial and why the average yield from the nation's rivers is rather small. Explanations of the rainfall-runoff relation are the core of applied hydrology, and this essential point has not been covered by the author.

Tables 2 to 5 need comment, for the conclusions reached by the author in connection with their use are subject to question. Table 2 contains no explanation of the absence of runoff data for the Yucatan Peninsula. Is it to be inferred that no gaging stations are operative here or that the topography consists of "sinks" that make customary surface drainage impossible? Nevertheless, runoff data for some 47,130 sq miles are missing. The author does not reveal how the discharges observed at "* * * nearly 450 measurement stations, located in basins with an area equivalent to 40% of the total land area of Mexico * * *" have been translated into mean annual runoff for the entire country containing 755,920 sq miles. The total mean annual runoff of 147,080,000 acre-ft is readily converted to inches of depth over the entire area and equals 3.6 in. The use of inches of depth to express runoff is much more indicative of relative magnitude than is the use of acre-ft and much more readily compared with inches of depth of rainfall.

The author has used data from "Floods; Their Hydrology and Control"[5] and has failed to note that its author, H. K. Barrows, M. ASCE, attributes the total mean annual runoff for the United States to only 2,428,123 sq miles or to about 80% of the total area (3,000,000 sq miles). More important, Mr. Garcia-Quintero has used a source of information which contains numerous errors.[9] It is to be hoped that, in the closing discussion, the author will recon-

[8] Associate Prof. of Civ. Eng., Univ. of Illinois, Urbana, Ill.

[5] "Floods; Their Hydrology and Control," by H. K. Barrows, McGraw-Hill Book Co., Inc., New York, N. Y., 1st Ed., 1948, p. 52.

[9] "Floods; Their Hydrology and Control," by H. K. Barrows, McGraw-Hill Book Co., Inc., New York, N. Y., 1st Ed., 1948 (Col. 5, Table 4–6, change the mean daily flow from the St. Lawrence Basin from "22,800 cu ft per sec" to "228,000 cu ft per sec").

cile his paper by reference to the original water supply papers or to other studies prepared by the United States Geological Survey.

The work of Walter B. Langbein, Assoc. M. ASCE, and others reported in 1949,[10] reliably indicates that the country-wide average annual runoff is 8.5 in. The ratio of average annual runoff in the United States to that in Mexico is, therefore, $\frac{8.5}{3.6}$ or 2.35, not 1.51 as given by the author in Table 5.

The writer would feel grateful to Mr. Garcia for including in his closure some information about ground-water hydrology and its relation to dry-weather flow of streams in Mexico. The writer would also like some explanation as to why substantially the same mean annual rainfall in the United States and Mexico (30 in.) produces 8.5 in. and 3.6 in., respectively, of runoff in these two countries.

GERARD H. MATTHES,[11] HON. M. ASCE.—The engineering profession is indebted to the author for his informative review of hydrologic conditions in Mexico. Little has appeared in print on this subject in American literature, aside from a few records published in the Water Bulletins of the International Boundary Commission of the United States and Mexico. Therefore, his review is doubly welcome to American engineers. The author makes clear that the primary objective of Mexico's engineers in establishing rainfall and stream-flow measuring stations has been to obtain data for use in effecting the fullest practicable utilization of Mexico's scant water resources for agricultural purposes. Only 6.8% of Mexico receives rainfall that is sufficient (or adequately distributed seasonally) for maturing crops. The few Mexican rivers that have perennial flows are located in this 6.8% area, which is shown in Figs. 3, 4, and 5 to lie chiefly along the southern Gulf coast.

Since the author's tabulations did not afford space to show the periods covered by the records, the writer wishes to point out that, in the matter of stream-flow records, stations were established in Mexico as early as 1900 and 1901. However, it was not until 1926, when Mexico's National Irrigation Commission was created, that the study of its water resources received its main impetus. Many of the meteorologic and hydrometric stations listed by the author were established by this commission. At the end of 1940, 205 rainfall-measurement stations and 199 stream-gaging stations had been placed in operation, and by 1946 their number had grown to 235 and 239, respectively.[12] The Water Resources Ministry, which took over the work of the commission in 1946, continued the establishment of stations until by 1950, as stated by the author, 450 gaging stations were in operation in Mexico. They supply data for use in planning irrigation projects. In so far as the writer is aware, gaging stations for use in flood control projects, like the one on the Papaloapan River in the State of Veracruz, were not established until much later. In short, there are still large areas for which no hydrologic records are available. As Mexico is a country subject to cataclysmic floods

[10] "Annual Runoff in the United States," by Walter B. Langbein and Others, *U. S. Geological Survey Circular No. 52*, Washington, D. C., June, 1949.

[11] Retired Cons. Hydr. Engr., New York, N.Y.

[12] "Labor de la Comisión Nacional de Irrigación en sus Veintiun Años de Vida," by Adolfo Orive Alba, "Irrigación en México," Vol. 27, No. 4, 1946, p. 13.

which annually take a large toll of human lives, flood control projects in time will call for the establishment of additional gaging stations.

The author has wisely refrained from deducing relationships between rainfall and runoff for specific watersheds, as affected by evaporation and different soil types. Owing to the peculiar climate, topography, and disturbed geological formations characteristic of Mexico, academic studies of this kind are likely to be of small help in practical problems. One factor, which American engineers have to contend with in rare cases but one which affects Mexican hydrology in many sections, is the occurrence of large closed basins that contribute no visible surface runoff to any river system. To illustrate, the drainage area of the Rio Bravo ("Rio Grande" in the United States) within the rim of the Rio Grande basin measures 335,000 sq miles, of which 163,100 sq miles yield no runoff to the river. Some of these closed basins are situated in parts of Chihuahua, Coahuila, and Durango on the Mexican side; other closed basins exist in Texas and New Mexico on the United States side of the river. Whatever ground-water movement finds its way from these basins into stream channels is as yet largely conjectural.

The relatively short periods covered by most records and, more especially, the unpredictable character of flood-flow intensities were responsible for the adoption of the system of building earth dams with rock fills in such a manner as to be capable of withstanding overtopping by floods during construction.[13]

[13] "Construction Technique of Passing Floods over Earth Dams," by Andrew Weiss, *Proceedings-Separate No. 40*, ASCE, Vol. 76, October, 1950.

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